Measurement of σ(Z+b)/σ(Z+j)

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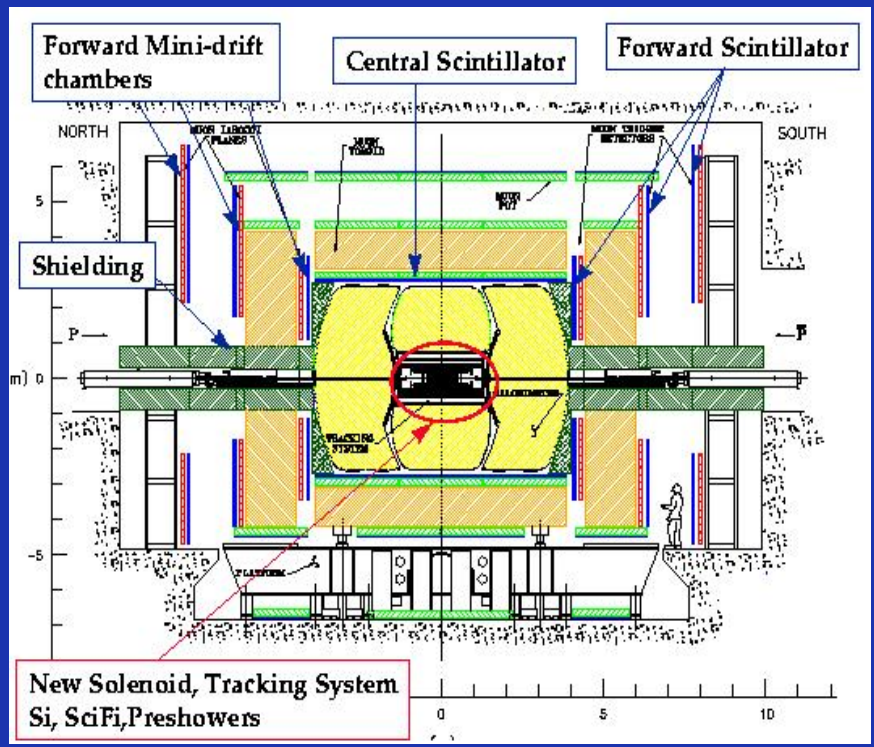
Tevatron Collider in Run II

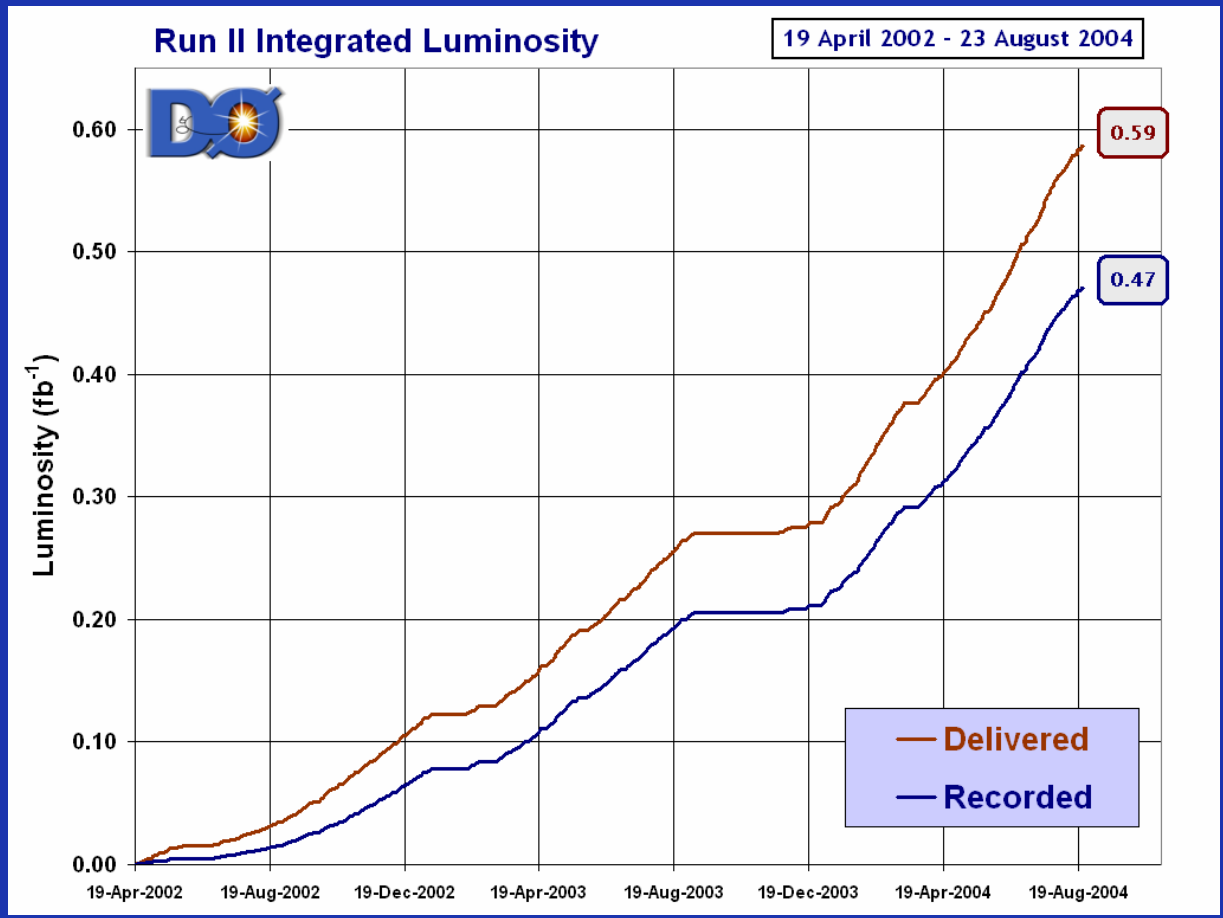
- Colliding protons and antiprotons at $\sqrt{s} = 1.96$ TeV
- 36 x 36 proton and antiproton bunches with 396 ns bunch crossing time
- Current peak instantaneous luminosity $1 \times 10^{32} cm^{-2} s^{-1}$

The DØ Detector



- New Tracking: Silicon and Fibers in 2T Solenoidal Magnetic Field
- New Central and Forward Preshower Detectors
- Liquid –Argon/Uranium Calorimeter
- Upgraded Muon System in 1.8T Toroidal Magnetic Field
- Upgraded DAQ & Trigger Systems: 50-60 Hz rate to tape

DØ Data Taking



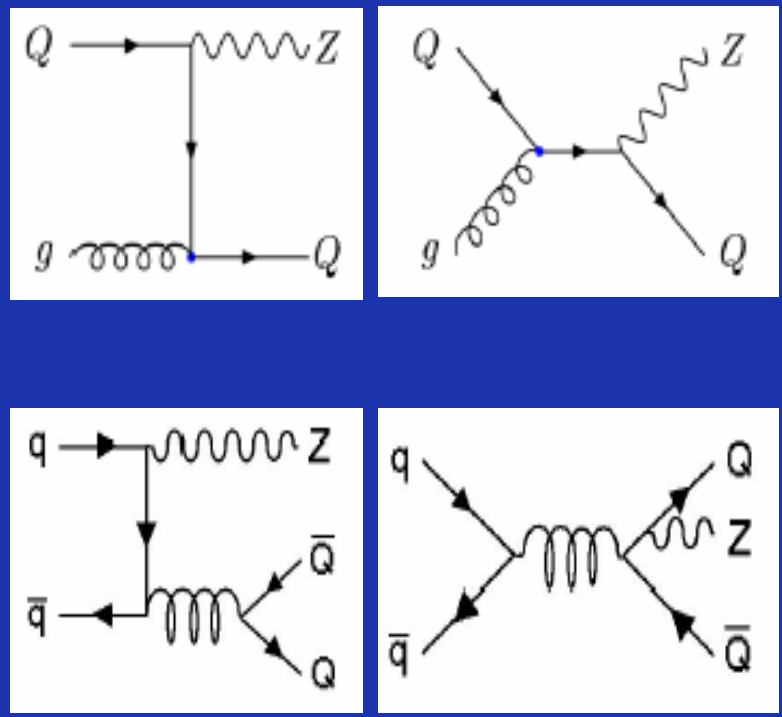
Delivered = 590 pb^{-1}

On tape = 470 pb^{-1}

- Run I = 130pb^{-1} recorded
- Results presented here will be based on ≈ 180 pb^{-1} of data

Z + Heavy Flavor Production

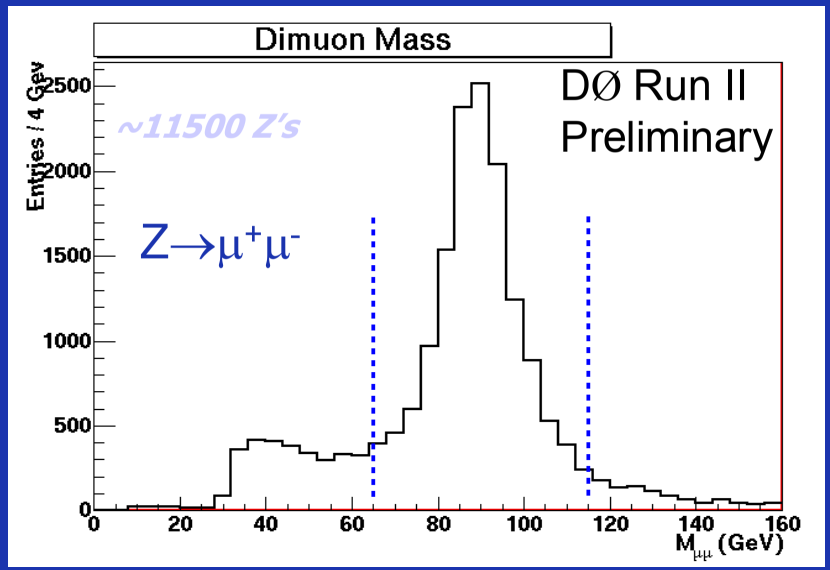
- Z + heavy flavor is background to Z+Higgs
- Z + single b-quark
  - Probe of b-quark PDF
  - b-quark PDF important for SUSY Higgs production ($gb \rightarrow bh$) and single top process ($qg \rightarrow tq'$)

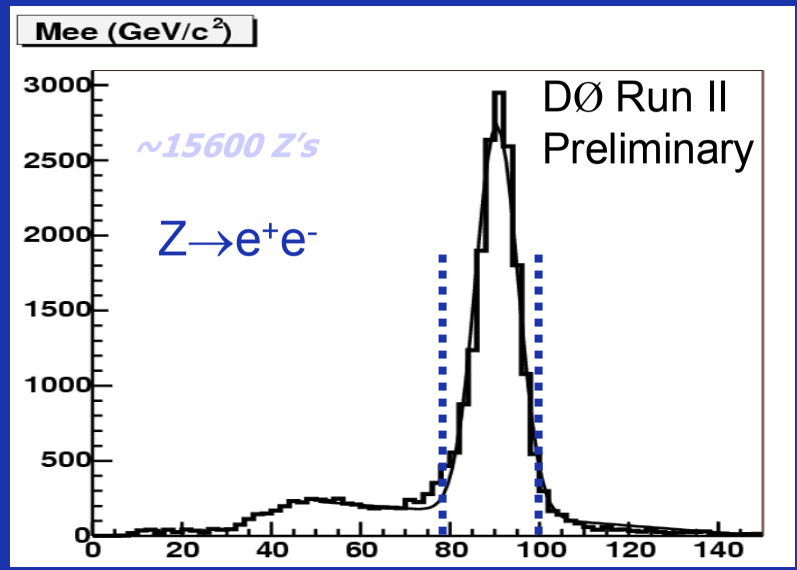


This analysis measures the ratio of Z+b and Z+j inclusive cross sections combining the dielectron and dimuon decay channels of the Z (many systematics cancel !)

Analysis: Event Selection

- Dimuon Channel:
  - Luminosity ≈ 180pb^{-1}
  - Reconstruct $Z \rightarrow \mu^+\mu^-$ events
    - 2 loose & isolated muons
    - p_T > 15 GeV and |η|<2.0
    - Track Match & Opposite sign
    - 65.0 < $M_{\mu\mu}$ < 115.0 GeV
- Dielectron Channel:
  - Luminosity ≈ 189pb^{-1}
  - Reconstruct $Z \rightarrow e^+e^-$ events
    - 2 isolated EM clusters
    - p_T > 15 GeV and |η|<2.5
    - At least one track matched
    - 80.0 < M_{ee} < 100.0 GeV

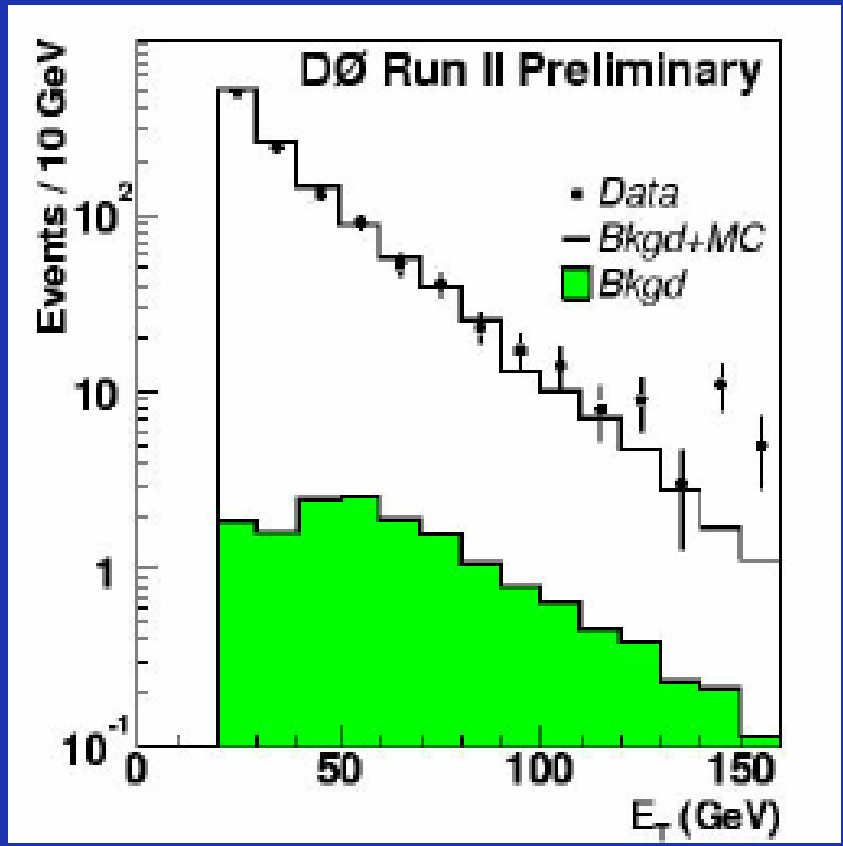




Jets

Looking for jets in Z events and applying b-tagging

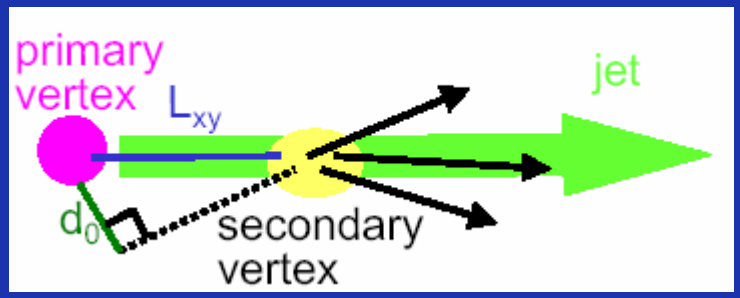
- Jet E_T > 20 GeV, $|\eta|$ < 2.5
- Run II cone algorithm: ΔR=0.5
- Taggable jets (=containing tracks for b-tagging) are required
- Event count:
  - Z + ≥ 1 calorimeter jet:
    - 2219 $Z \rightarrow e^+e^-$ and 1754 $Z \rightarrow \mu^+\mu^-$
  - Z + ≥ 1 taggable jet:
    - 1658 $Z \rightarrow e^+e^-$ and 1406 $Z \rightarrow \mu^+\mu^-$
  - Z + ≥ 1 b-tagged jet:
    - 27 $Z \rightarrow e^+e^-$ and 22 $Z \rightarrow \mu^+\mu^-$



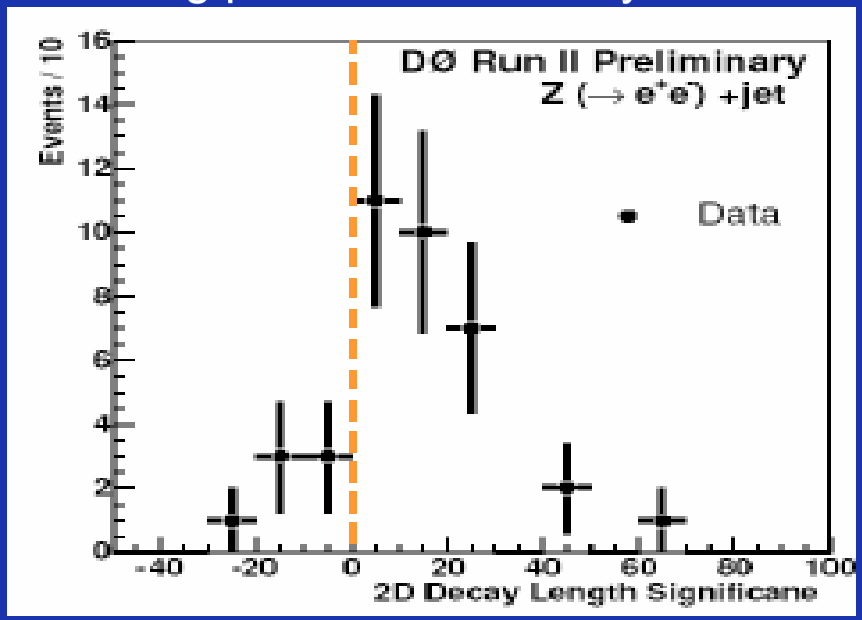
E_T of taggable jets (dimuon & dielectron channels combined)

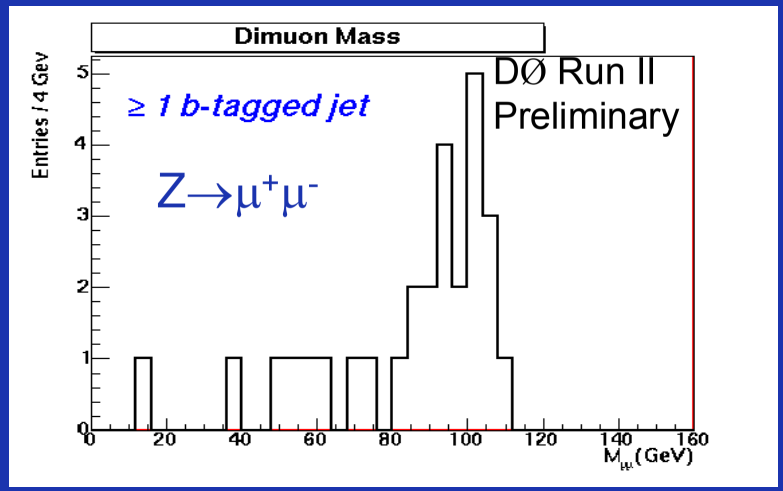
b-Tagging

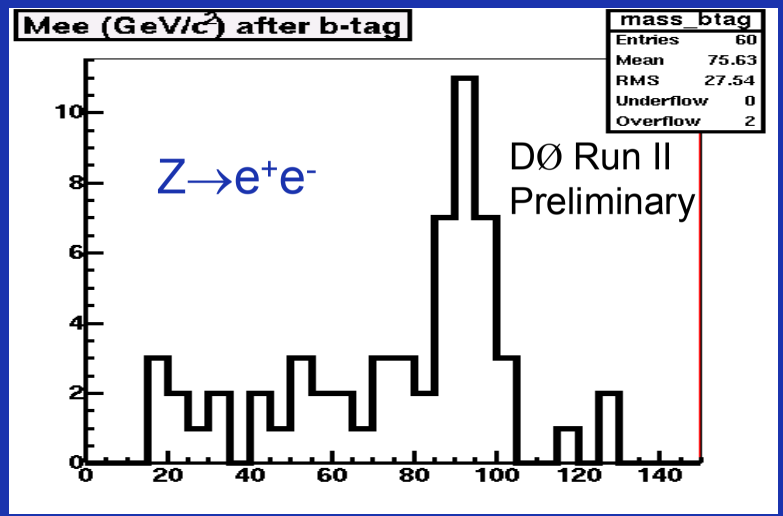
Applying Secondary Vertex b-tag:



Asymmetry in decay length significance is indicating production of heavy flavor:







Dilepton Mass of b-tagged events

Disentangling light, c, b contributions

- After background is subtracted, two equations, one before and one after b-tagging is applied, allow one to determine the contributions from different flavors in the remaining events:

$$\left(N - N_{bckg}\right)_{before} = t_b N_B + t_c N_C + t_l N_L$$

$$\left(N - N_{bckg}\right)_{after} = \varepsilon_b t_b N_B + \varepsilon_c t_c N_C + \varepsilon_l t_l N_L$$

- N = # of events with b,c and light jets
- ε = tagging efficiencies for different jet types
- t = taggabilities for different jet types
- Use light and b-tagging efficiency from data
- c-tagging efficiency from MC and scaled for data/MC difference in b-tagging
- $N_C = 1.69 N_B$ from theory (MCFM NLO calculation)

$$\longrightarrow \quad \frac{\sigma(Z+b)}{\sigma(Z+jet)} = \frac{N_B}{N_B + N_C + N_L}$$

Results

$$\frac{\sigma(Z+b)}{\sigma(Z+j)} = 0.023 \pm 0.004(stat) \pm 0.002(syst)$$

- Theory predicts 0.018*
- Large part of systematic error from tagging efficiency and background estimation
- Cross checks with different b-tagging algorithms
  - Soft lepton tagger
  - Impact parameter tagger

*J. M. Campbell, R. K. Ellis, F.Maltoni and S.Willenbrock, *Phys. Rev. D69 (2004) 074021*

Systematics

- b/c tagging efficiency (13.4%):
  - Largest source of systematic uncertainty
- Jet Energy Scale (6.7%):
  - Jet energies are fluctuated up and down by 1 standard deviation
- Background estimation (6.2%):
  - Based on different background subtraction methods
- Mistag rate (3.3%)
- Taggability (2.8%):
  - A difference observed in t_b/t_L using different MC samples is regarded as an uncertainty
- $\sigma(Z+c)/\sigma(Z+b)$ (2.5%):
  - Uncertainty from theory
- Muonic vs Hadronic jets (1.8%):
  - Analysis does not differentiate between muonic and hadronic jets
  - Tagging efficiencies were derived from muonic jets

Summary and Outlook

- A first preliminary Run II measurement of the inclusive cross section ratio of σ(Z+b) to σ(Z+j) was performed and the ratio was found to be 0.023 ± 0.004(stat) ± 0.002(sys)
- Systematic errors are dominated by b-tagging efficiency estimation
- Stay tuned for more results at the winter conferences: cross section measurement of Z+b and Z+$b\bar{b}$